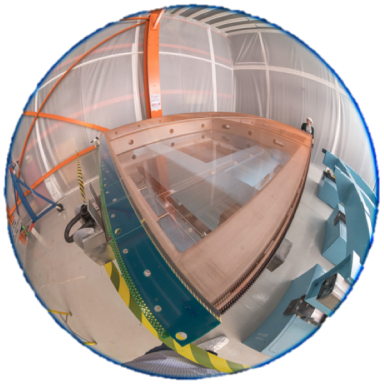


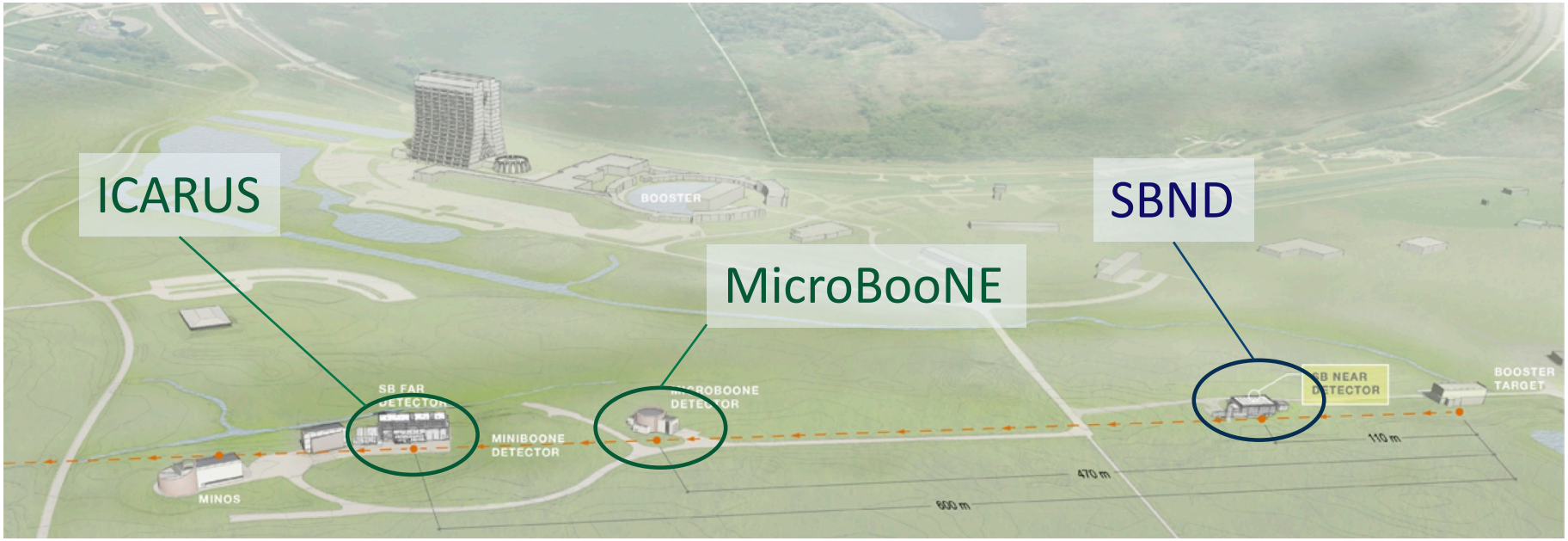
Short-Baseline Near Detector (SBND)

52nd Fermilab Users' Meeting

June 13th 2019

Nicola McConkey, on behalf of the SBND collaboration

Short-Baseline Neutrino Program



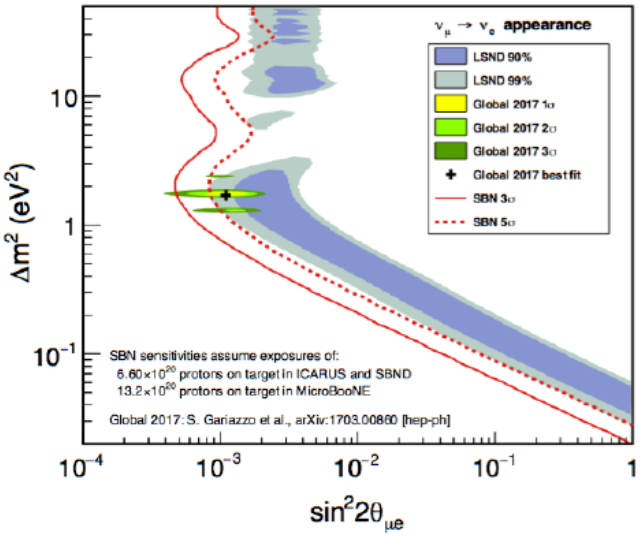
Detector	Baseline (m)	Active LAr mass (tonnes)
SBND	110	112
MicroBooNE	470	87
ICARUS T-600	600	476

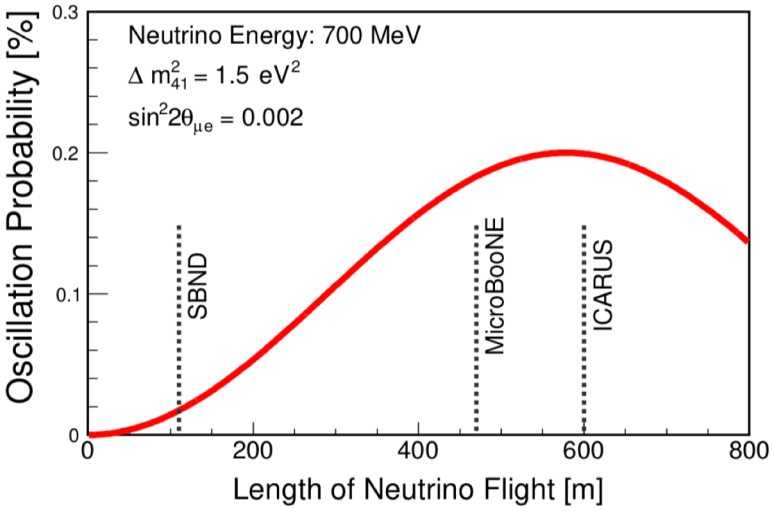
- Three-detector measurement program in the Fermilab Booster Neutrino Beam
  - Low energy: peak around 1 GeV
- Liquid argon Time Projection Chambers (LAr TPC)
  - Same nuclear target and detector technology

SBND Physics: neutrino oscillations and sterile neutrinos

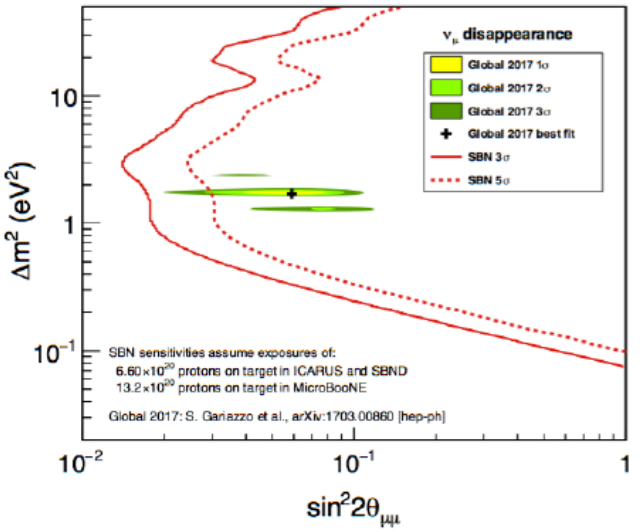
- SBND's role in SBN program is to measure the unoscillated neutrino flux
  - Crucial for the sensitivity of oscillation measurement
  - Highly correlated interactions in near and far detectors
    - Same detector technology and target
    - Decreases effects of neutrino flux and neutrino interaction uncertainties on the measurement
  - Controls systematic uncertainties for sterile neutrino search

[S. Gariazzo et al, arXiv:1703.00860v3]



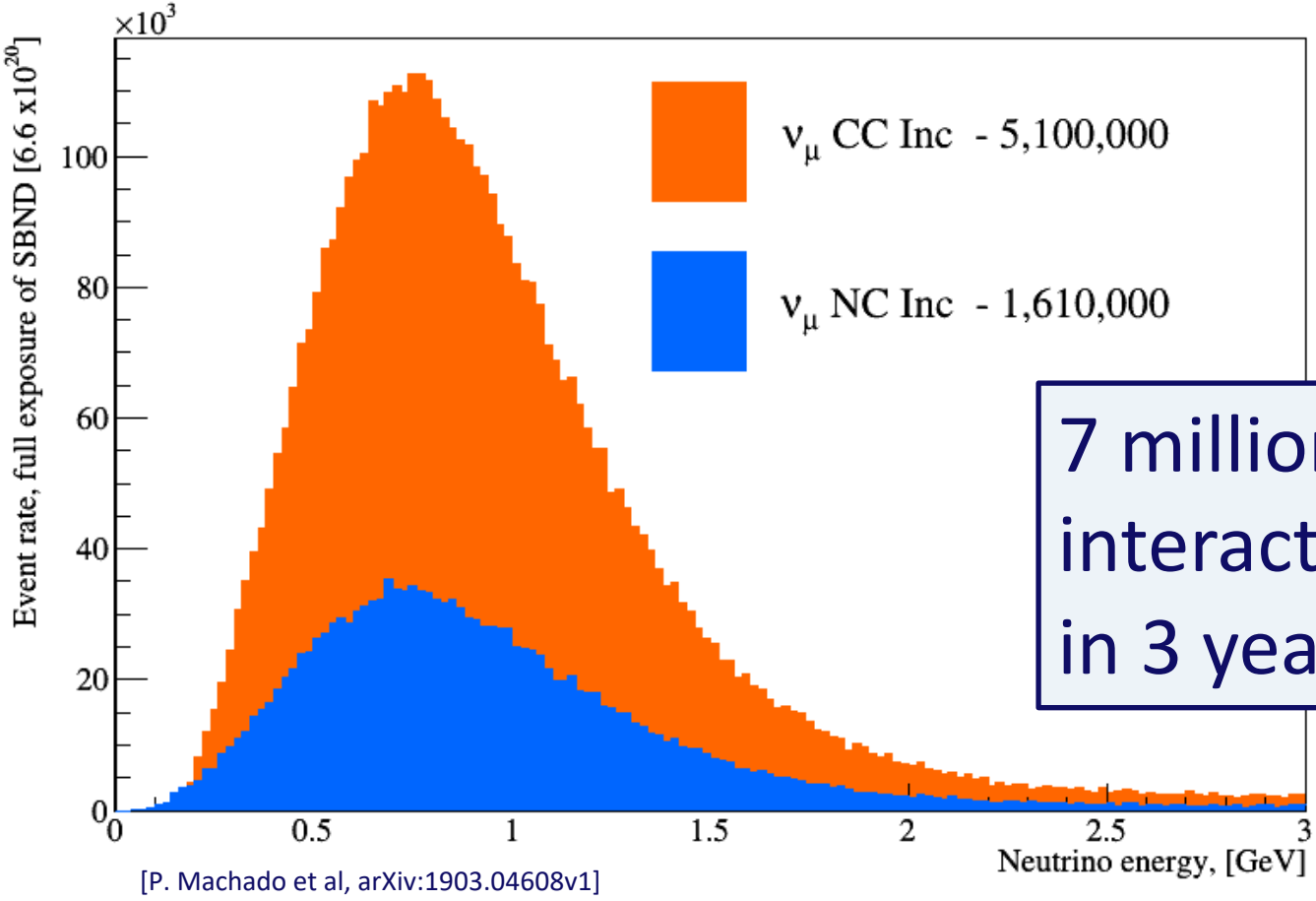


[P. Machado et al, arXiv:1903.04608v1]



SBND physics: neutrino-argon interactions

- SBND will make the world's highest statistics cross-section measurements on liquid argon

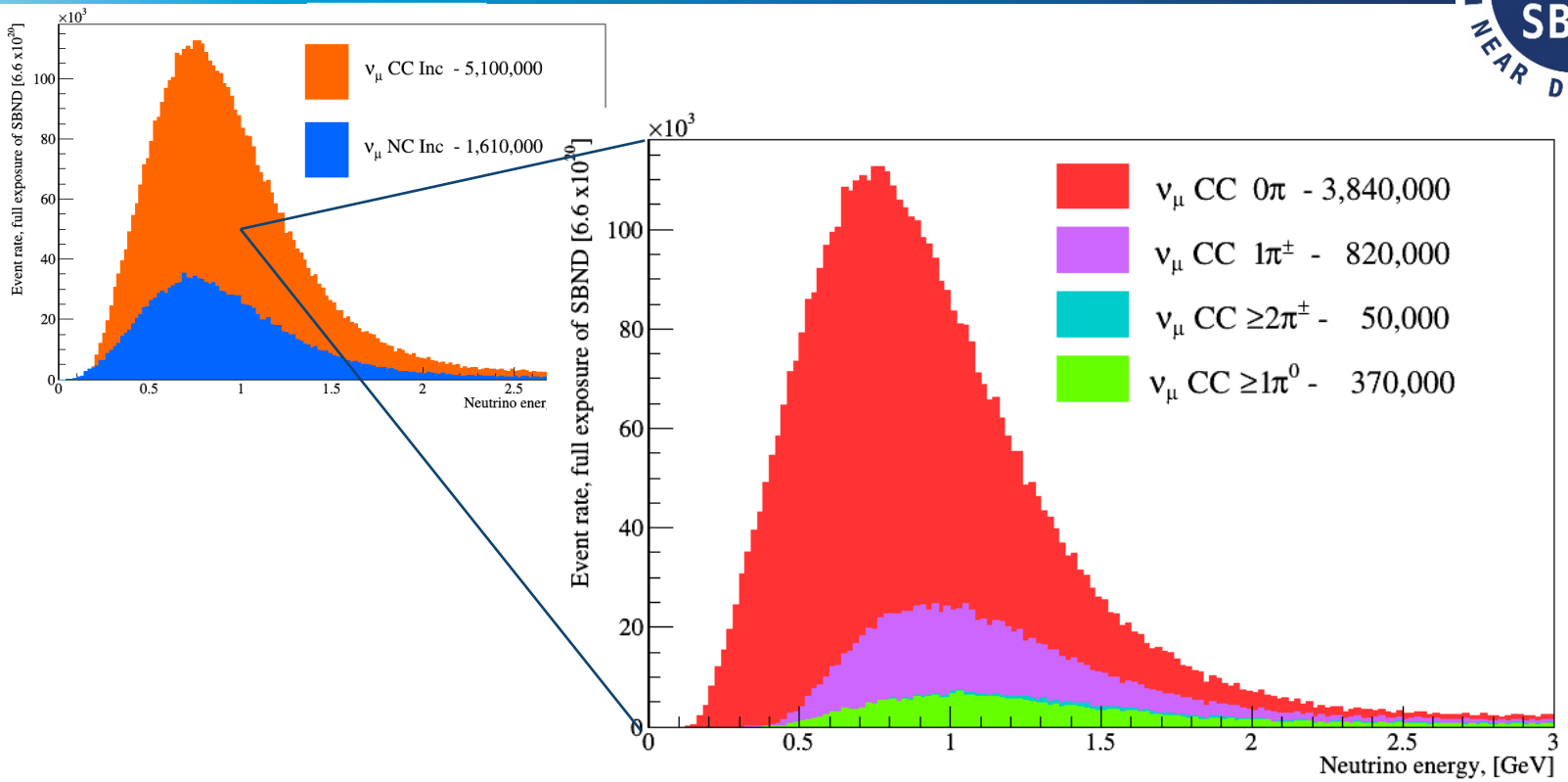


[P. Machado et al, arXiv:1903.04608v1]

7 million ν_μ interactions in 3 years

50,000 ν_e interactions in 3 years

SBND physics: neutrino-argon interactions



- High interaction rate and LAr TPC technology allows precision measurements of exclusive event topologies
- Can quantify nuclear effects in ν-Ar scattering with ν_μ and ν_e CC 0π
- Direct experimental quantification of nuclear effects and impact on rates, final states and kinematics
  - SBND data will inform neutrino MC generators and discriminate between final state interaction models
  - Especially important in low energy (1GeV) regime

SBND Physics Program

- Short-Baseline Neutrino physics: neutrino oscillations and sterile neutrinos

  ICARUS talk, MicroBooNE talk – this session

- Neutrino-argon interaction physics

  Poster: Reconstruction and selection tools for charged-current muon neutrino inclusive cross sections in SBND - Tom Brooks

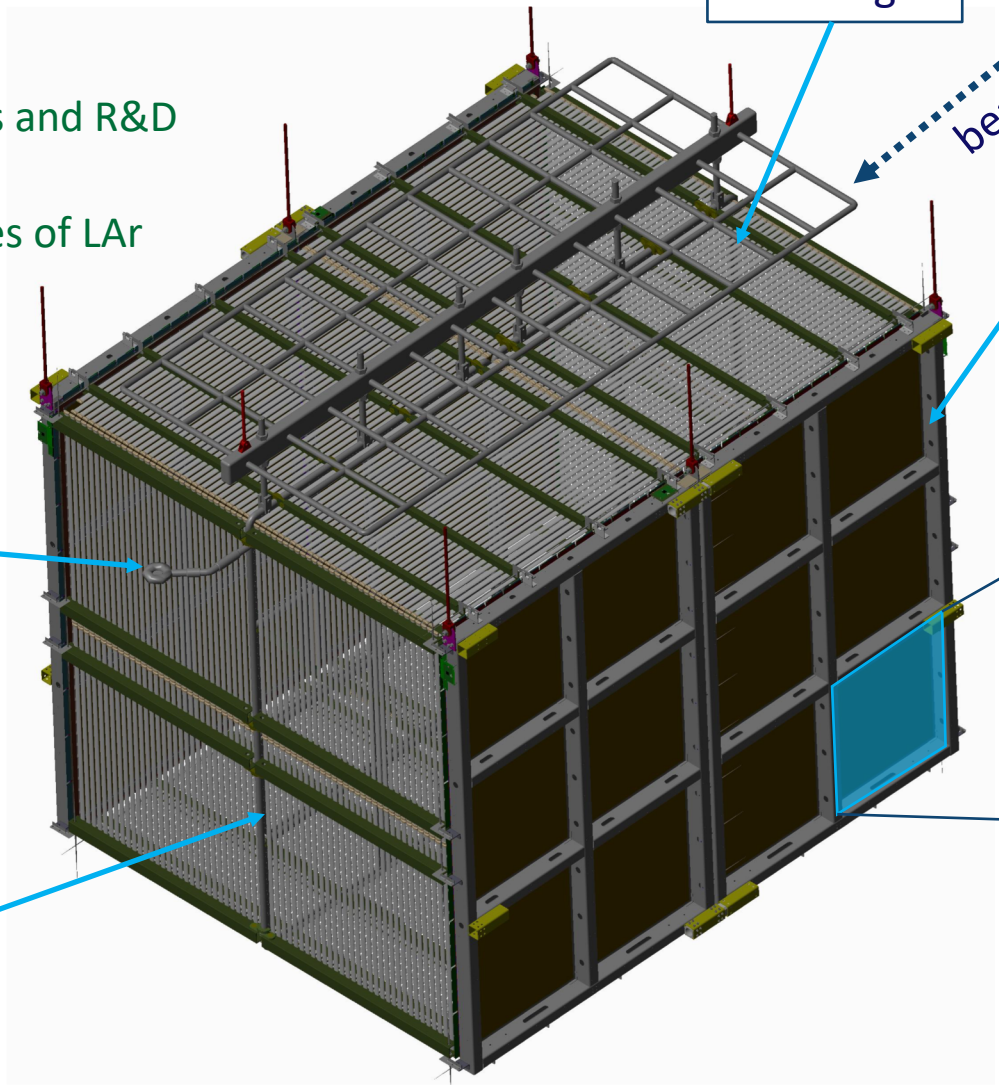
- Beyond Standard Model physics

  Paper: The Short-Baseline Neutrino Program at Fermilab - Machado, Palamara and Schmitz - arXiv:1903.04608v1 [hep-ex]

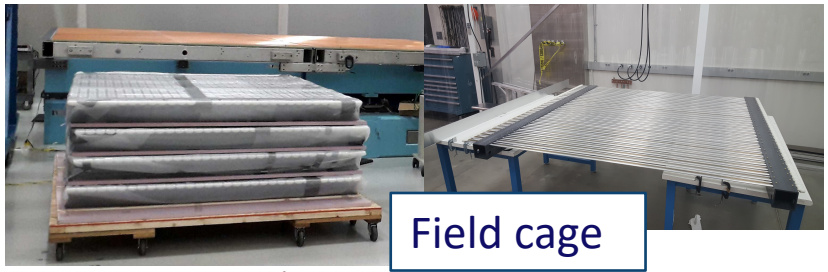
The Short-Baseline Near Detector

- A new LAr TPC detector!
  - Neutrino physics and R&D opportunities
  - 112 active tonnes of LAr
  - Active volume:

    4m x 4m x 5m

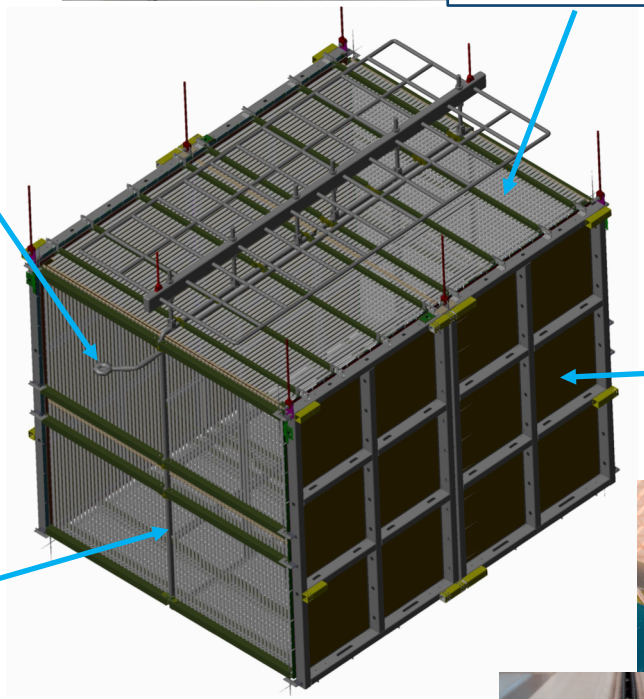


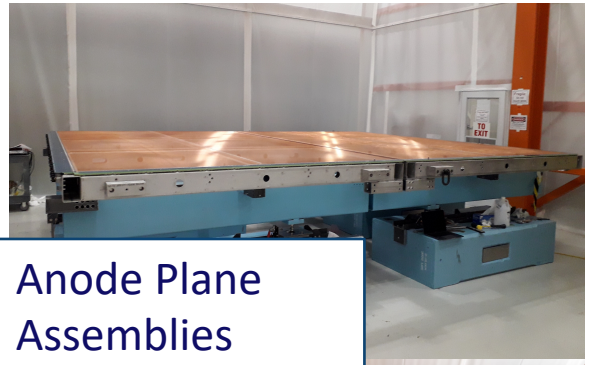
The Short-Baseline Near Detector



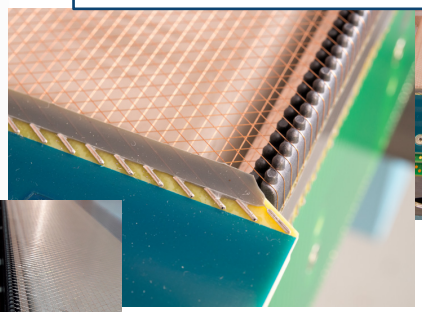
Field cage

High Voltage Feedthrough

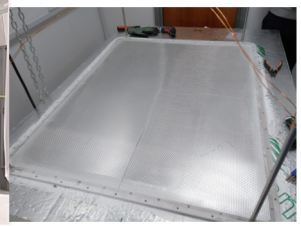


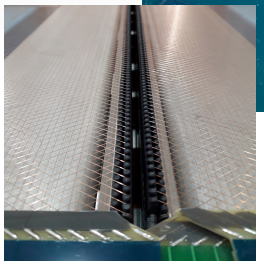


Anode Plane Assemblies (4 frames)



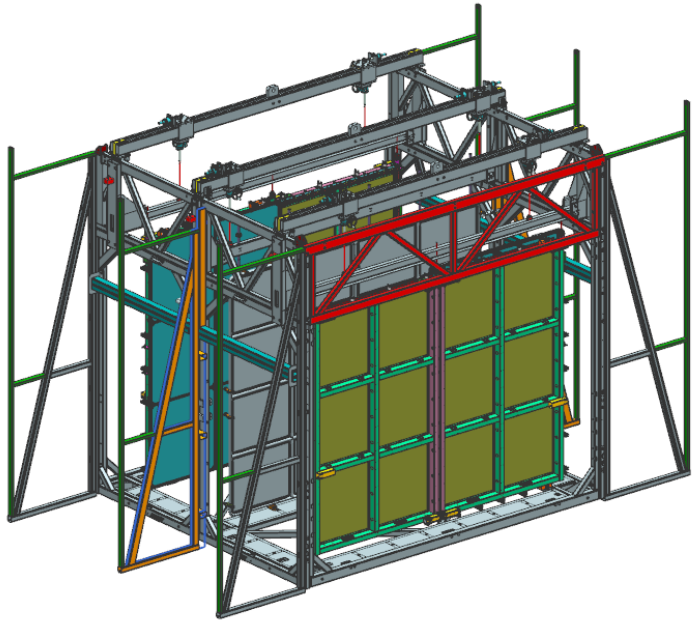
Cathode Plane Assembly: (2 frames)





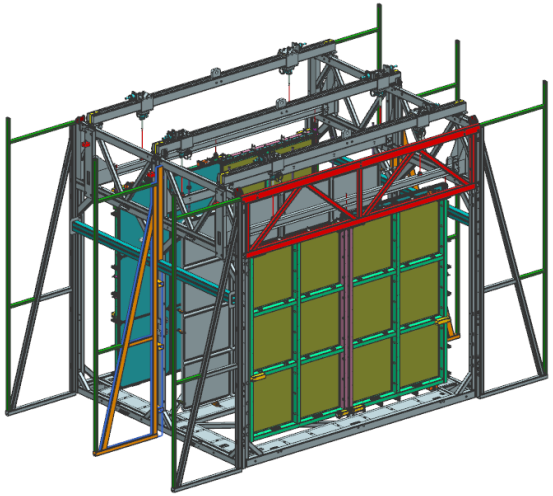
Current status

- Work ongoing in 3 locations:
  - TPC assembly, DAQ and cold electronics testing at DAB
  - Cryogenics installation at SBN-ND
  - Cryostat pre-fabrication at CERN
- Major TPC components and DAQ hardware all at Fermilab
- First Cold Electronics at Fermilab and tested
- TPC alignment and transportation frame is under construction

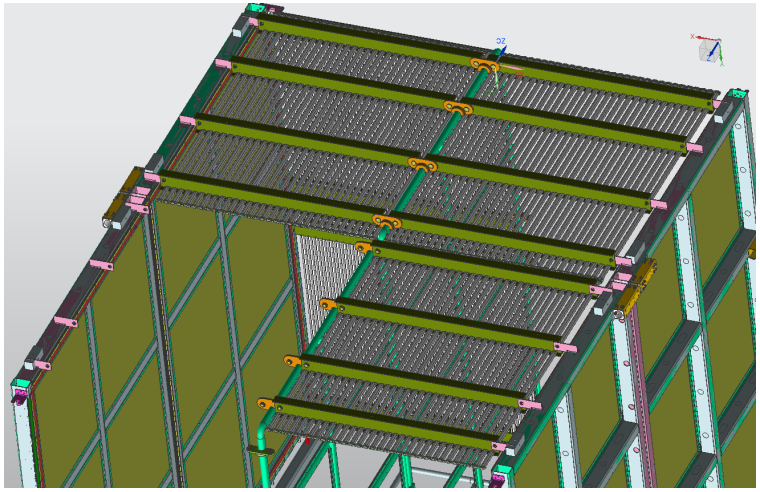


TPC assembly

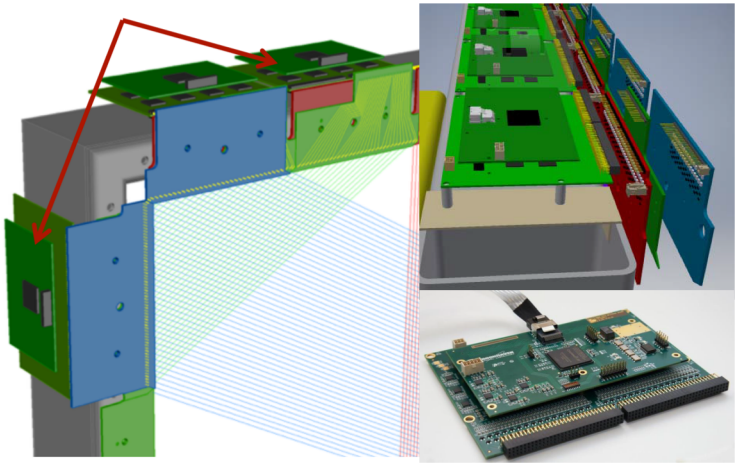
1) Install APAs and CPA



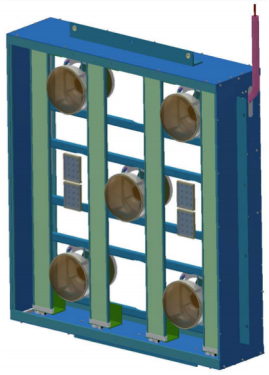
2) Install Field cage



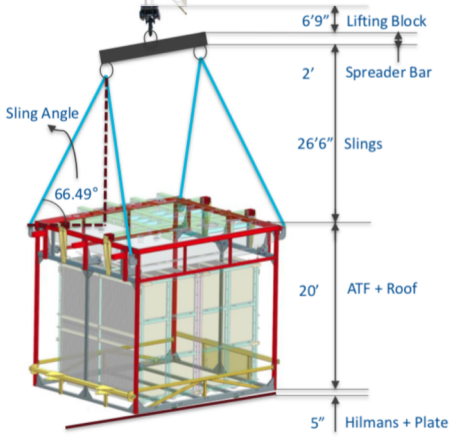
3) Install cold electronics



4) Install photon detection system

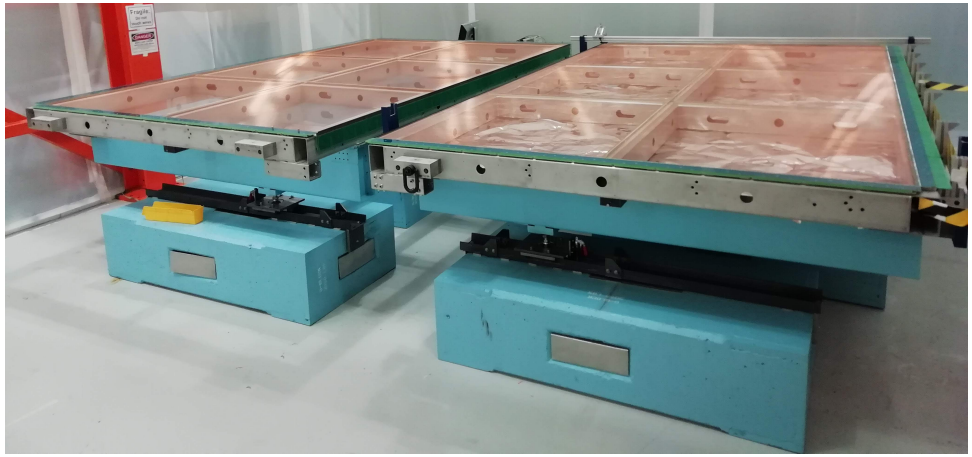


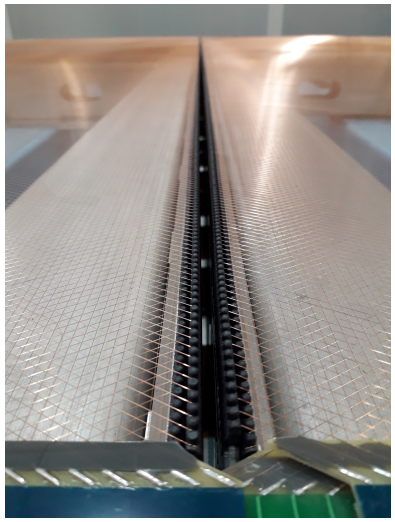
5) Move to SBN-ND detector hall!

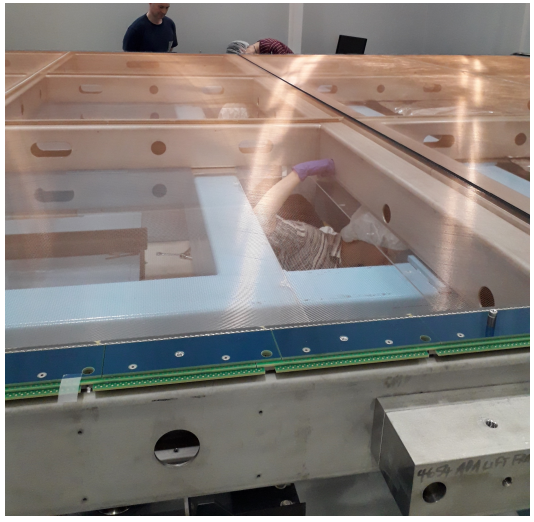


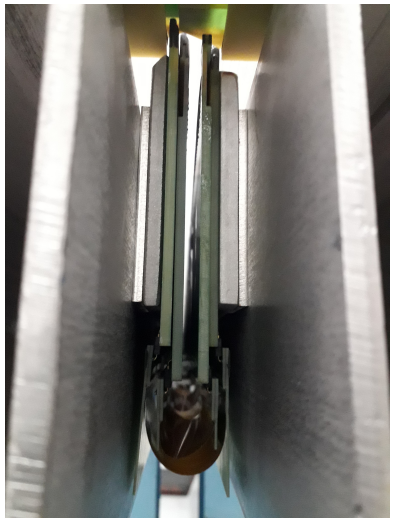
APA assembly

- Four APA frames produced at 2 wiring sites
- APAs are electrically and mechanically coupled at Fermilab
- Mechanical coupling of the APA
  - Precise alignment of APA frames using laser tracker technology
  - Attachment of APA with bolts and attachment blocks
- Electrical coupling of the APA
  - Readout on top and sides: cold electronics readout will be entirely in argon (FE ASIC and ADC)
    - Jumper connectors between APA frames







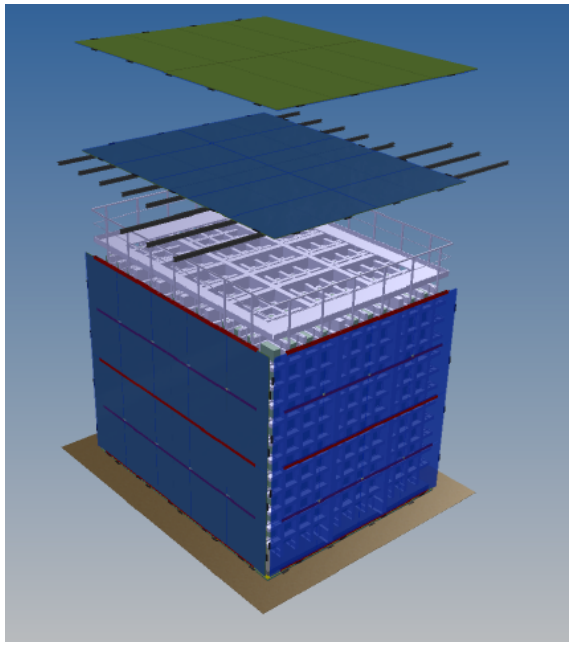


Electronics, DAQ, Cosmic tagger

- Cold Electronics
  - Production concluding at BNL
  - Front End Mother Board testing ongoing at Fermilab
  - Successful integration testing with APA

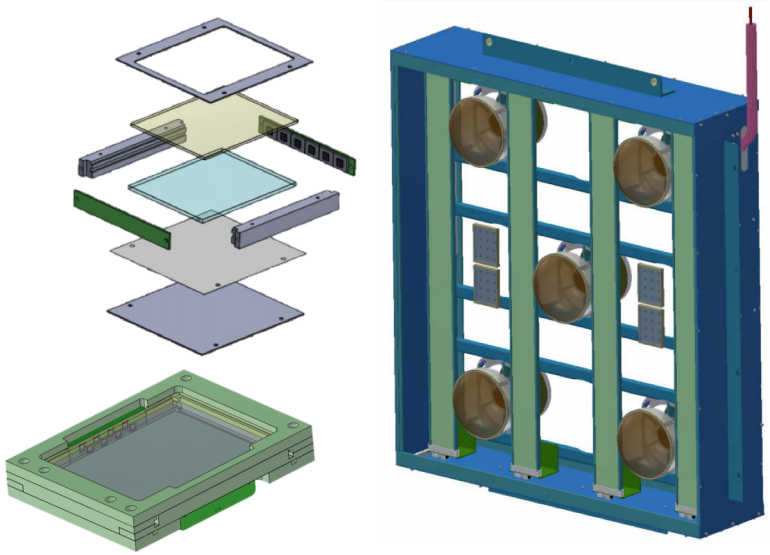
- DAQ test-stand at DAB
  - Production hardware plus prototypes under test
  - Integrating existing BNL and Nevis systems into shared SBN framework

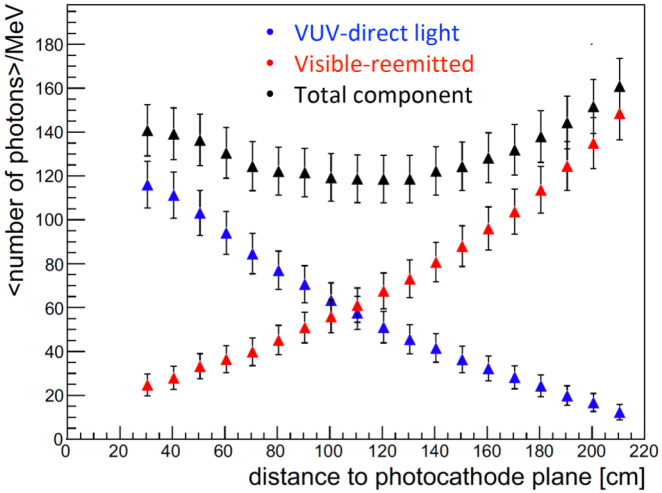
- Surface detector with concrete overburden
  - Tool to mitigate the cosmic ray background
- Cosmic ray tagger with nearly 4π coverage of the detector



Photon Detection System

- Modular photon detection system mounted behind APAs
- Photomultiplier Tubes
  - Wavelength shifter coating on 80%
- Reflector foils to be mounted at the cathode
  - Improves the uniformity of collected light
- ARAPUCA R&D
  - Arapuca
    - A device for “trapping” photons to increase the active area of SiPM
    - Dichroic filters
  - X-ARAPUCA
    - Arapuca concept with wavelength shifting guide for increased detection efficiency
    - Readout electronics R&D

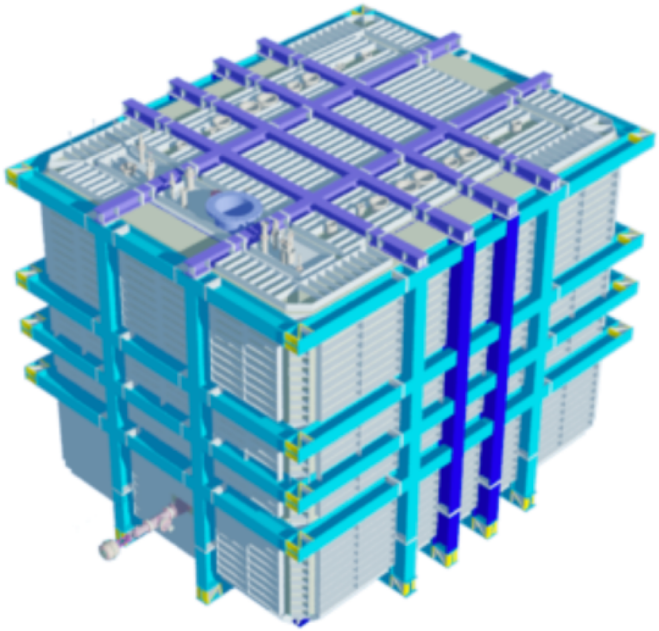




[D. Garcia-Gamez, Journal of Physics: Conf. Series 888 (2017) 012094]

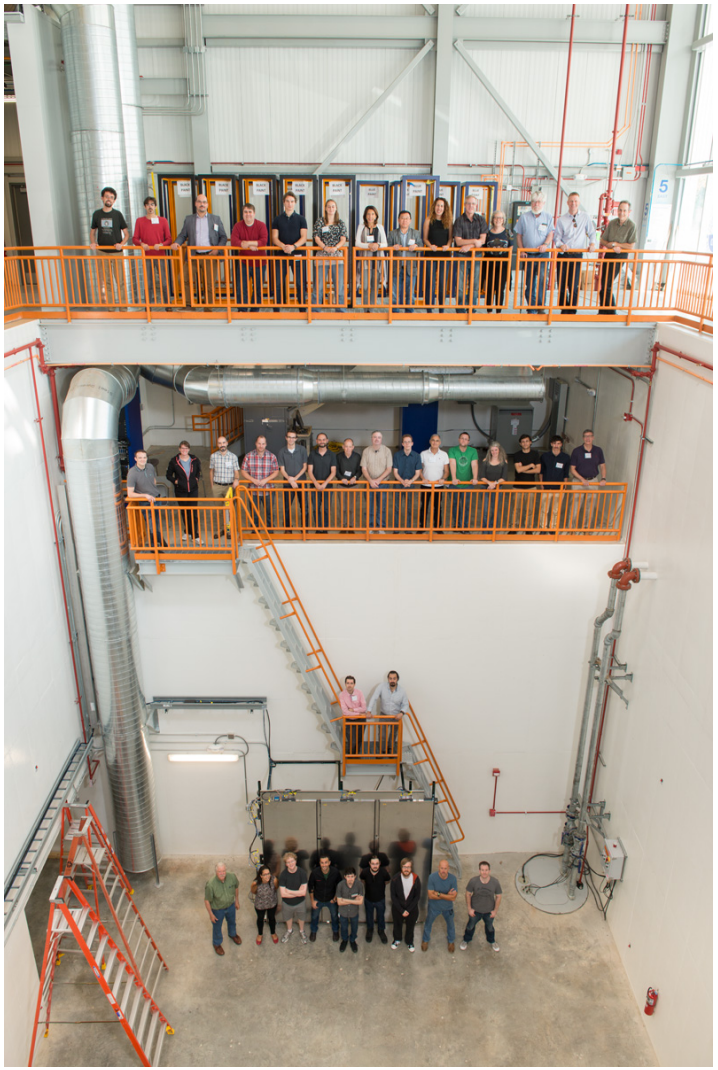
SBND Membrane cryostat

- Currently under construction at CERN
- 3rd generation prototype for DUNE
- Shipment and assembly at FNAL SBN-ND in fall 2019



Summary and outlook

- Exciting physics ahead for SBND!
- Detector assembly ongoing
  - Most major components already delivered to FNAL
  - Completion of SBND TPC construction fall 2019
- Cryostat fabrication is progressing well at CERN.
  - Installation at FNAL starts fall 2019
- ND building cryogenics installation has started
- Commissioning in 2020 and first neutrino data in 2021

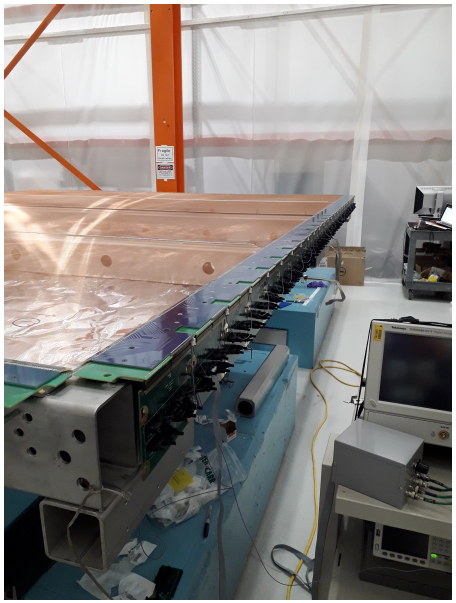


Backup

APA assembly

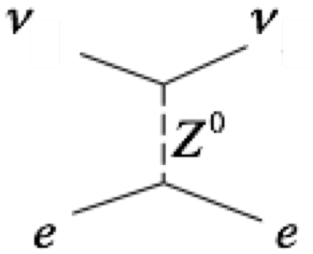
- Electrical coupling of the APA
  - Readout on top and sides: cold electronics readout will be entirely in argon (FE ASIC and ADC)
    - Jumper connectors between APA frames
  - QC checks of continuity for both U and V layer across jumpers
    - First plane: all wires connected successfully!



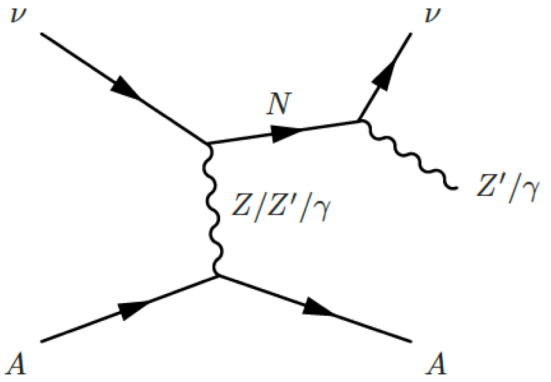



SBND physics program

1. High statistics measurement of neutrino-argon interactions:
   - ν_μ-CC *and* ν_e-CC and NC interactions
   - Precision studies of neutrino-argon cross section measurements in the GeV region
   - Absolute flux measurement with electron – neutrino scattering
   - Tuning of cross-section models
   - Rare event processes

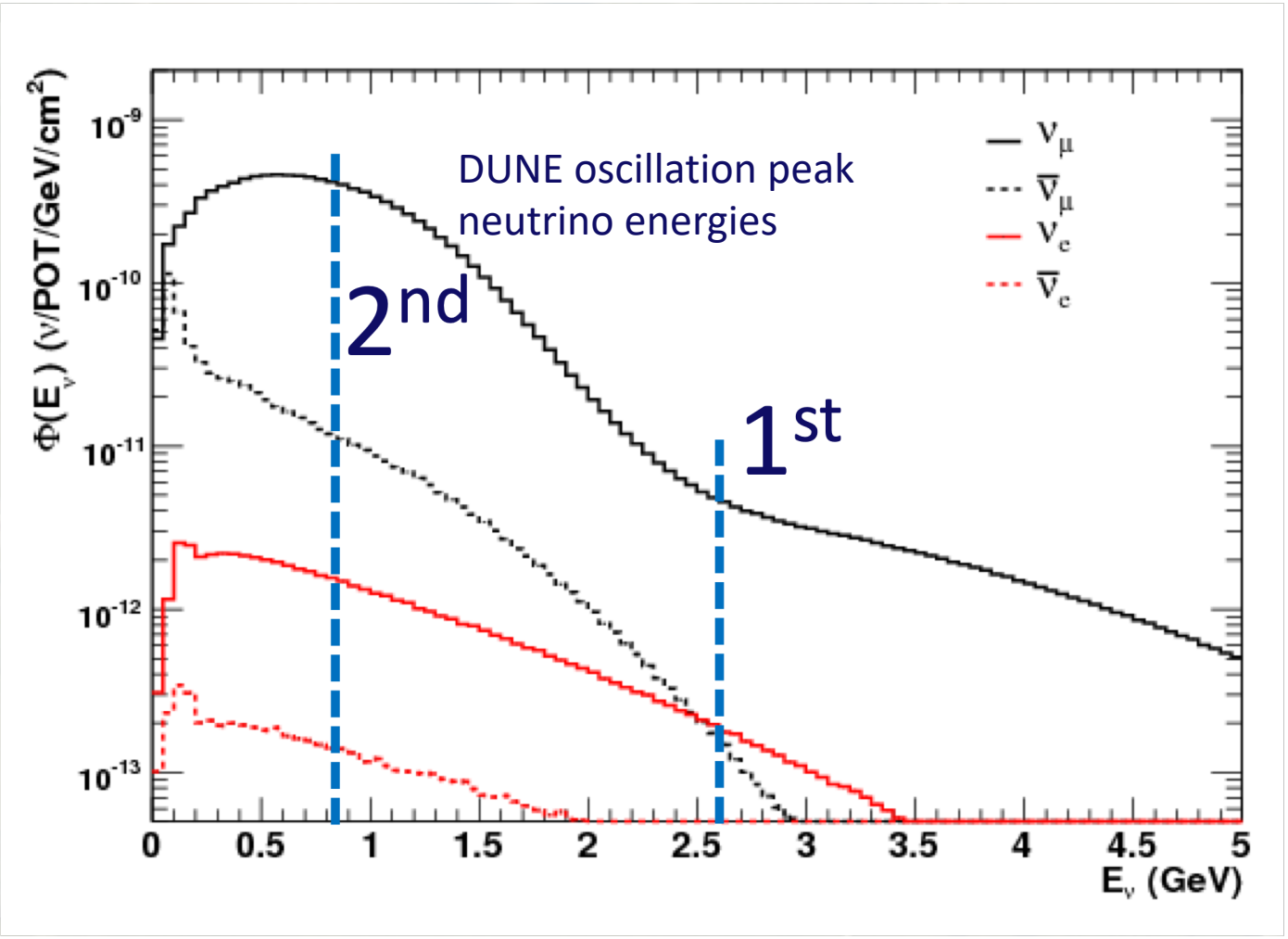


2. Search for Beyond Standard Model physics
   - Search for millicharged particles
   - Neutrino tridents
   - Dark neutrino sectors



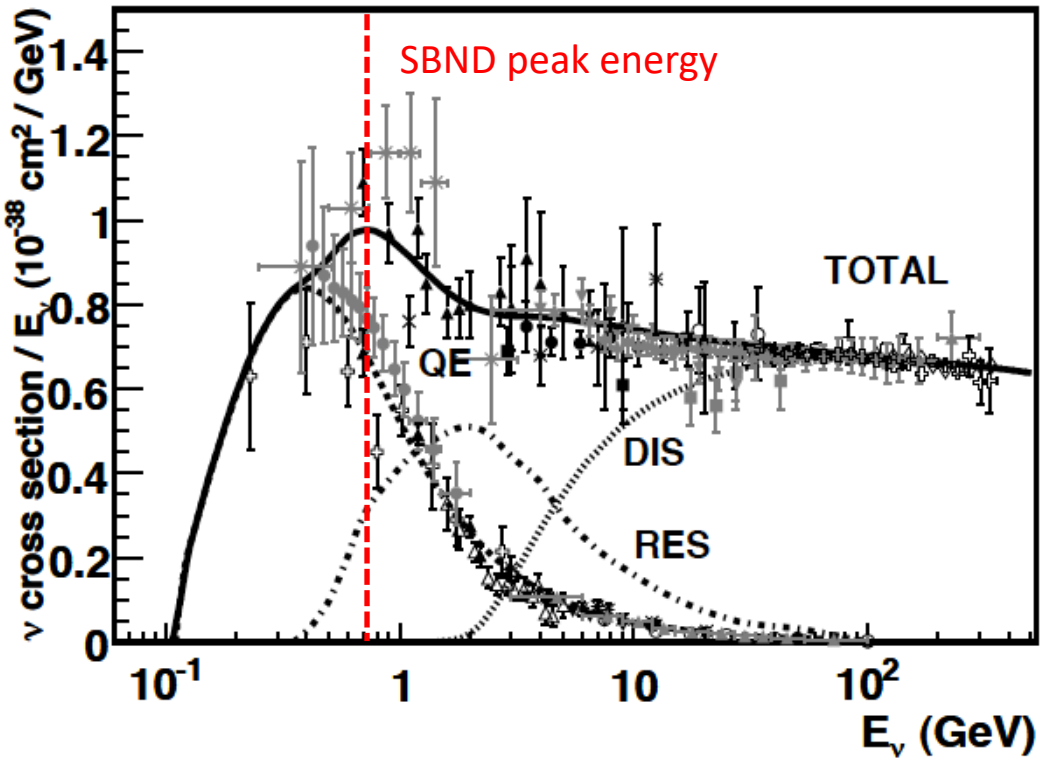
Relevance for DUNE

- Interactions at energies relevant for DUNE oscillation physics



SBND Cross sections in context

- Energy of SBND interactions is in CCQE / resonance transition region



[Formaggio, arXiv:1305.7513]

SBN-ND building status

- Cryogenics work at ND building ongoing this summer